

Climate and Agriculture: Variability, Change, and What Can Be Done To Be Prepared....

should we be alarmed or bored?

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Southeast Climate

EXTENSION | Advancing Climate Extension in Agriculture



Agriculture, weather, and climate

Take-home message...

- Yield variability (much of it resulting from climate variability): a leading concern
- Persistent (long-term) changes in climate (temperature and precipitation) might increase yield variability and bring unexpected challenges
- Improving plants
- Improving management

Short term

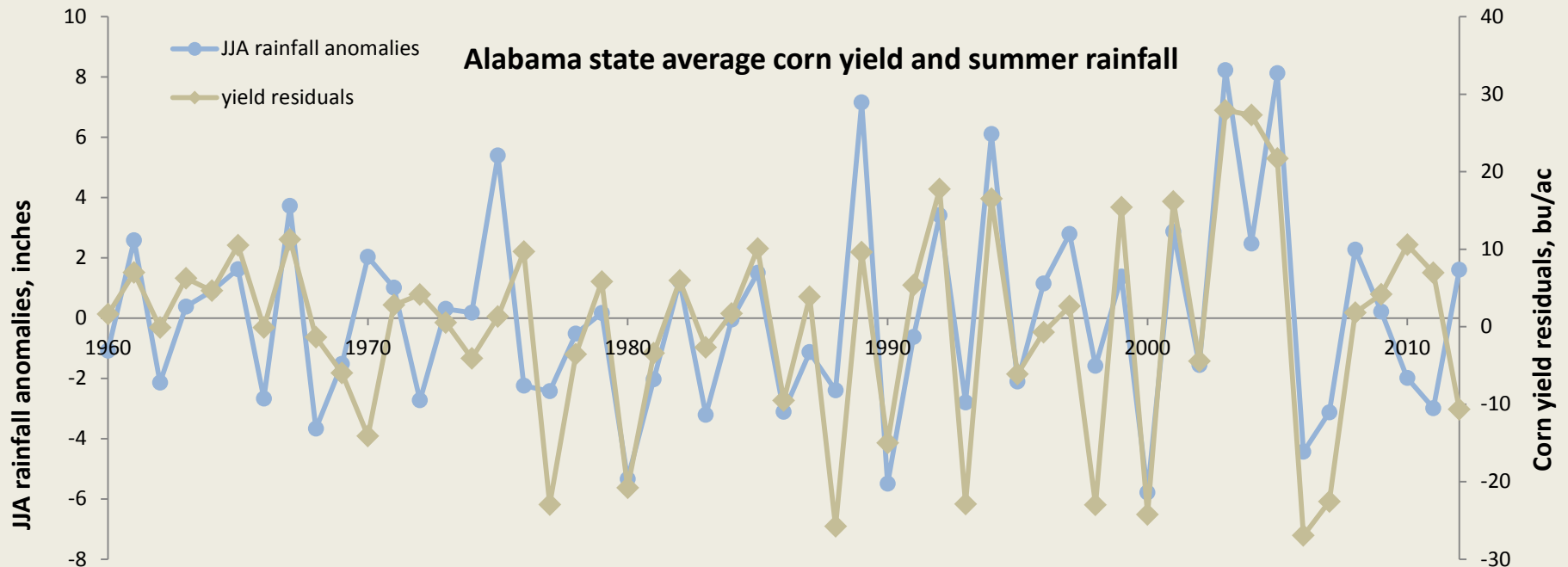
Long term

Strategies to
Adapt

Agriculture, weather, and climate

The most ancient conversation among farmers...
the weather

- Weather (individual events – minutes to days)
- Climate (averaged weather – months and longer)



Agriculture, weather, and climate

Why does climate matter?

- Risks: from variability to change – what do farmers think?
- Irrigated and dryland systems
 - 72% dryland in U.S.
 - 82% dryland globally



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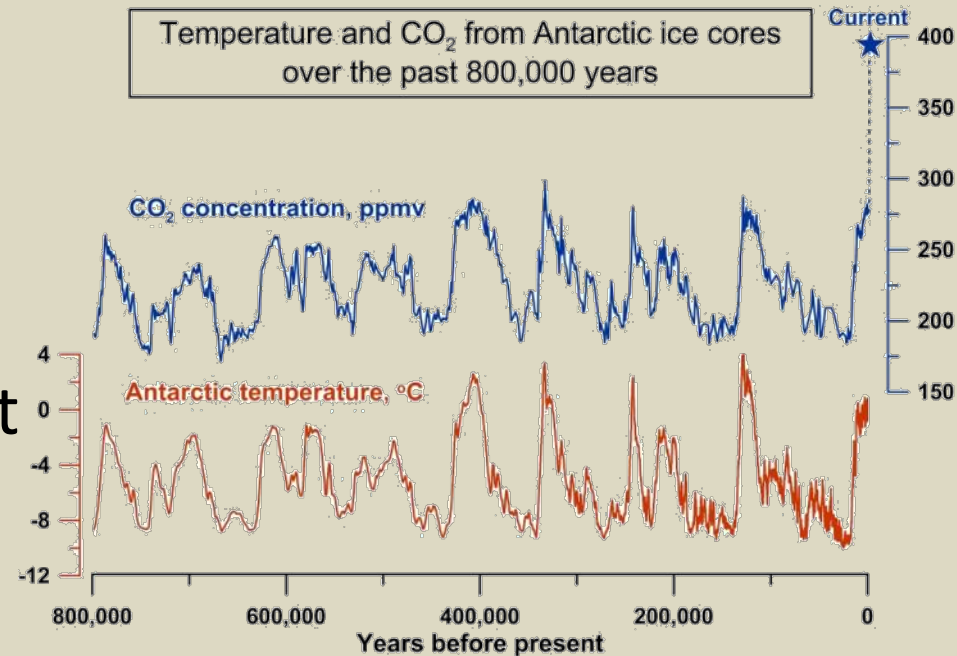
American Farmland Trust

1-800-431-1499

Climate Change: fundamentals

Climate change: as old as our planet

- The attribution debate... human-caused, natural, somewhere in the middle?
- Greenhouse effect – we wouldn't be here without it... a 0°F (-18°C) planet
- CO₂ – leading or lagging temperature change?



Climate Change: fundamentals

Significance of CO₂

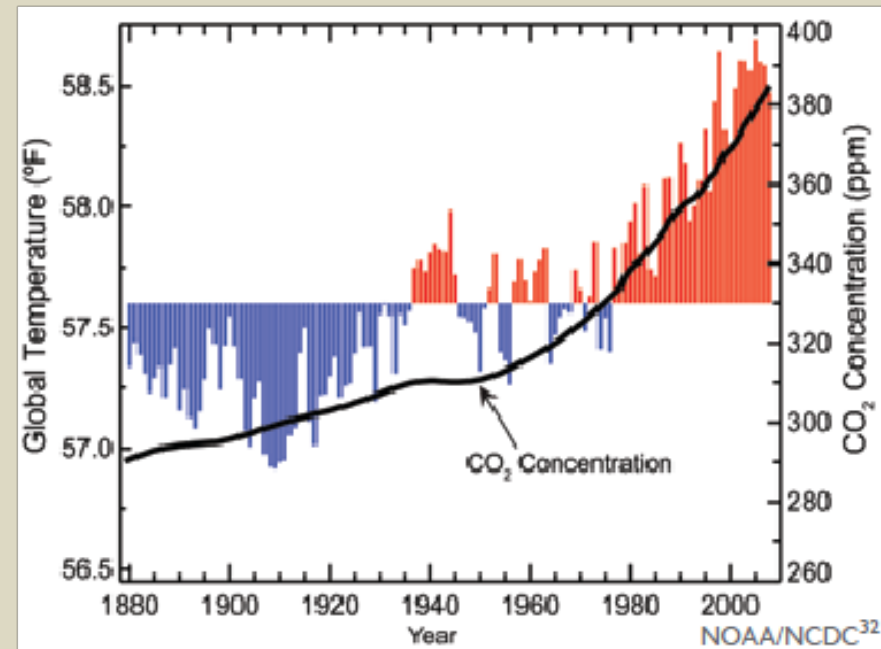
- The attribution debate...

Water vapor: 50%

Clouds: 25%

CO₂: 20%

Global Temperature and Carbon Dioxide



Climate Change: fundamentals

Global changes: temperature¹

- Challenge – choice of time periods gives a multitude of historical changes

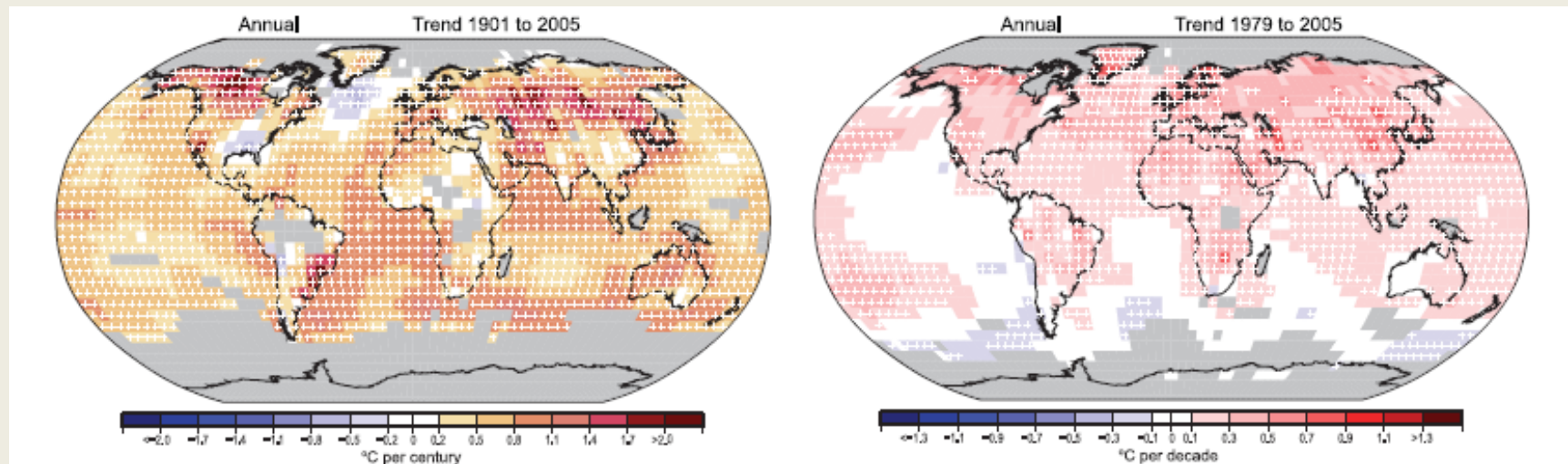
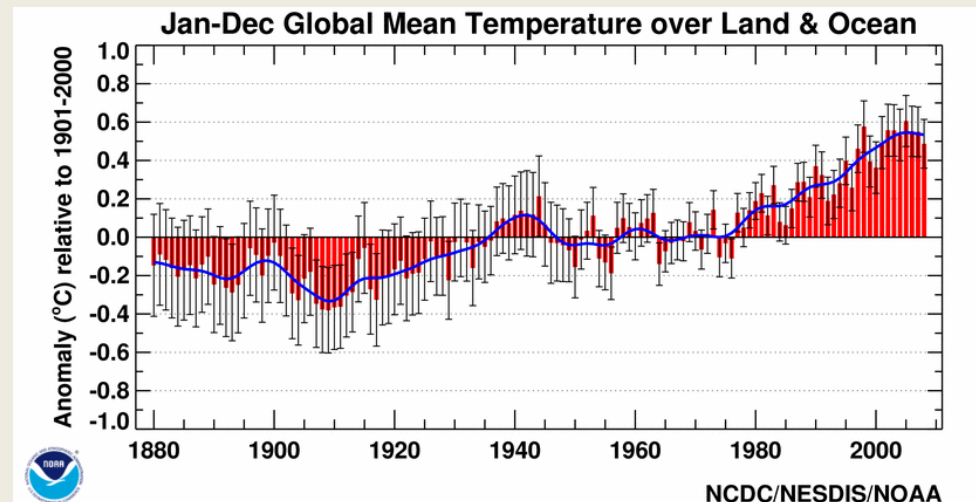
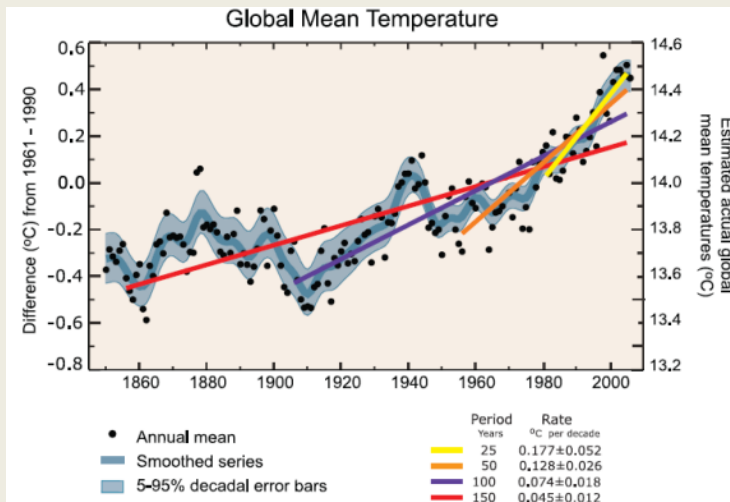


Figure 3.9. Linear trend of annual temperatures for 1901 to 2005 (left; °C per century) and 1979 to 2005 (right; °C per decade). Areas in grey have insufficient data to produce reliable trends. The minimum number of years needed to calculate a trend value is 66 years for 1901 to 2005 and 18 years for 1979 to 2005. An annual value is available if there are 10 valid monthly temperature anomaly values. The data set used was produced by NCDC from Smith and Reynolds (2005). Trends significant at the 5% level are indicated by white + marks.

Climate Change: fundamentals

Global changes: temperature

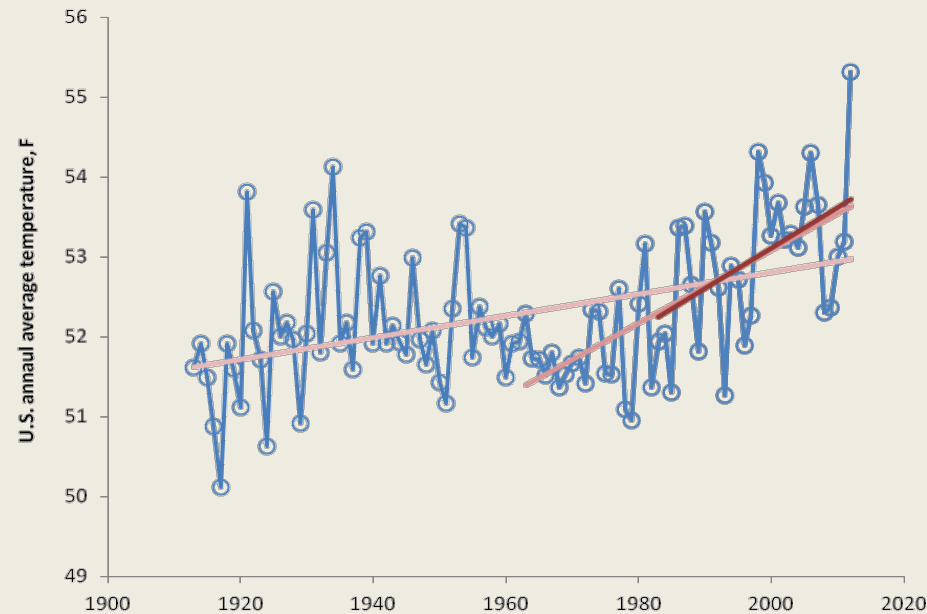
- Global surface temperatures have increased about 1.3 °F (0.74°C) in the 100 years from 1906-2005
- Linear trend for the past 50 years: global temp increase was 0.23°F/decade (0.13°C/decade) - nearly twice that of past 100 years



Climate Change: fundamentals

U.S. changes: temperature¹

- U.S. surface temperatures increased about 1.36 °F (0.75°C) in last 100 years (1913-2012)¹
- Linear trend for the past 50 years: U.S. temp increase was 0.46°F/decade (0.25°C/decade) – more than 3x that of past 100 years
- Midwest and northern Great Plains: 7°F increase in avg. winter temperature (last 30 years)²



¹ <http://www.ncdc.noaa.gov/temp-and-precip/time-series/>

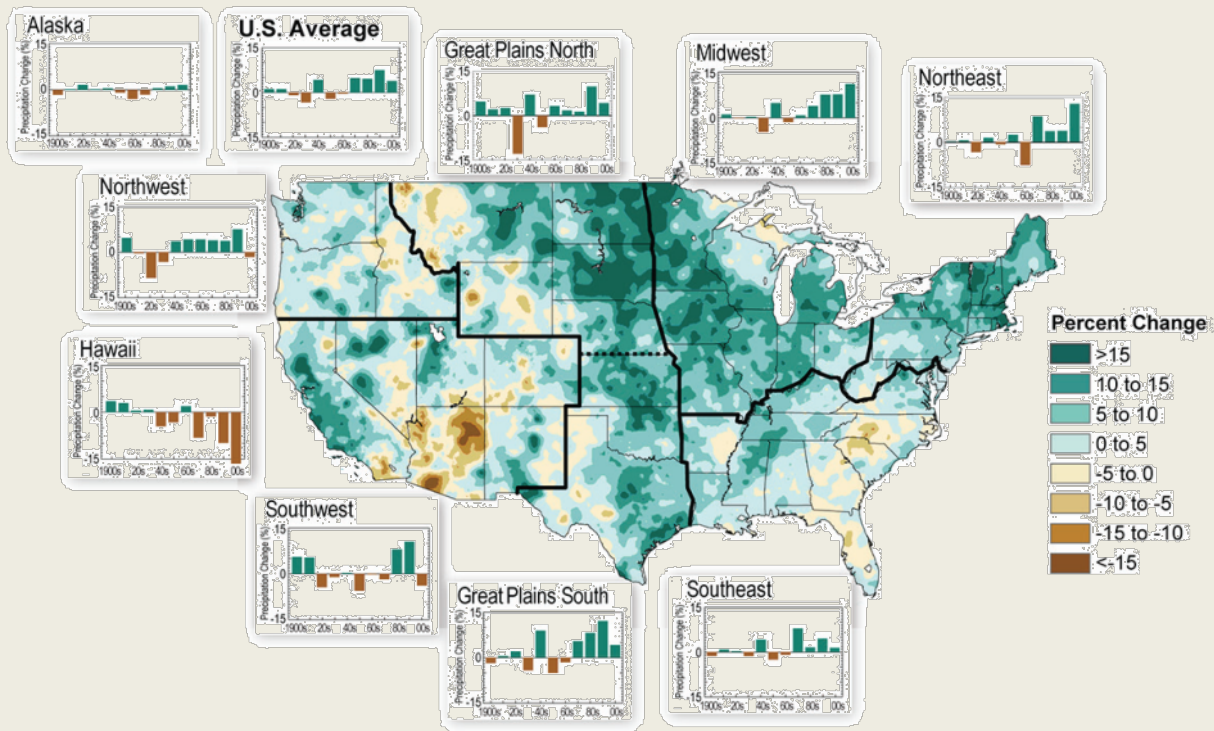
² USGCRP (2009). *Global Climate Change Impacts in the United States*. Karl, T.R., J. M. Melillo, and T. C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

Observed changes – historical: temperature

Climate Change: fundamentals

U.S. changes: precipitation

Observed U.S. Precipitation Change



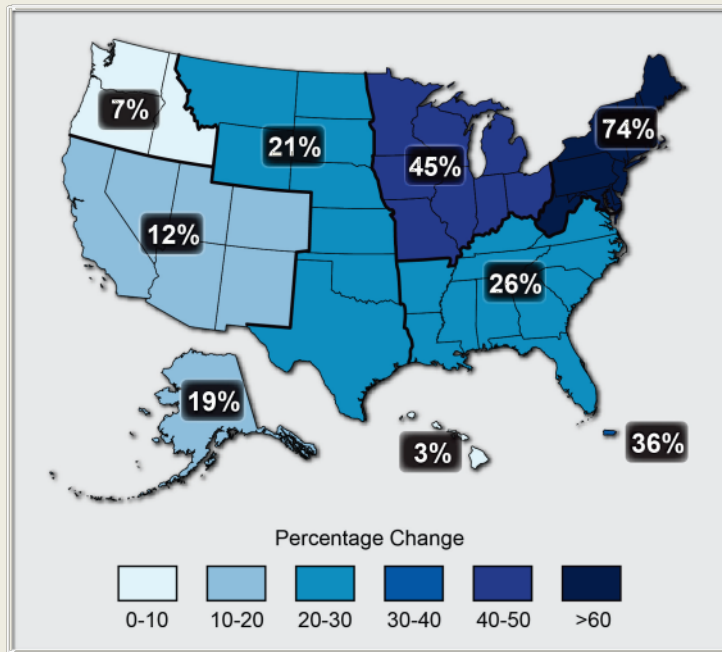
The colors on the map show annual total precipitation changes (percent) for 1991-2011 compared to the 1901-1960 average, and show wetter conditions in most areas

Climate Change: fundamentals

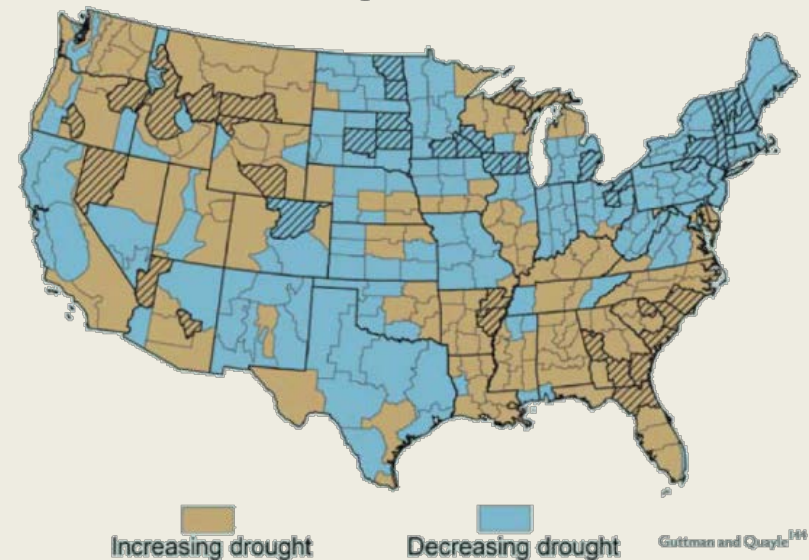
U.S. changes: precipitation

- Rainfall trend toward more high-intensity events (more rainfall variability) – this is CRITICAL!!!

Percentage Change in Very Heavy Precipitation



Observed Drought Trends 1958 to 2007



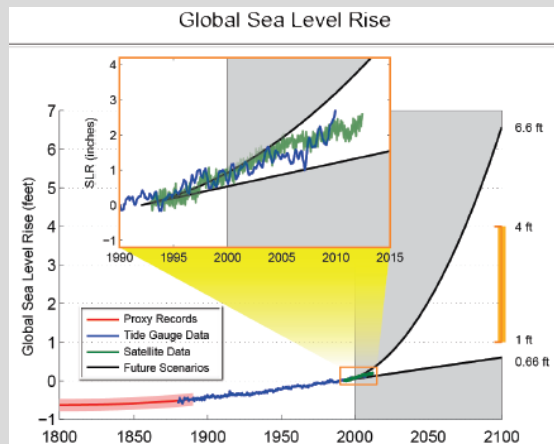
Trends in end-of-summer drought as measured by the Palmer Drought Severity Index from 1958 to 2007 in each of 344 U.S. climate divisions.¹⁴⁴ Hatching indicates significant trends.

Climate Change: projections

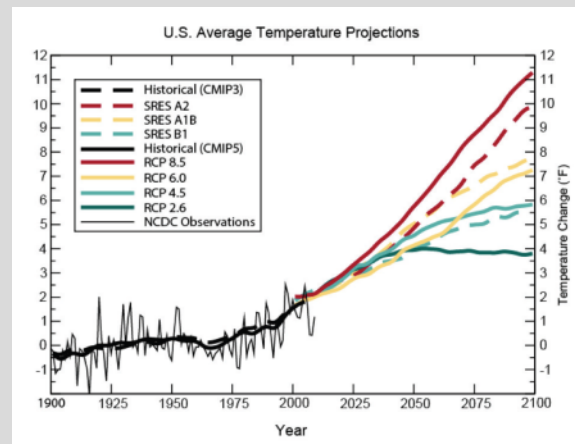
Rising seas, higher temperatures, **more episodic rainfall...** by 2100

- 1 to 4 feet of sea level rise by 2100
- 4 to 11°F temperature rise by 2100 in U.S.

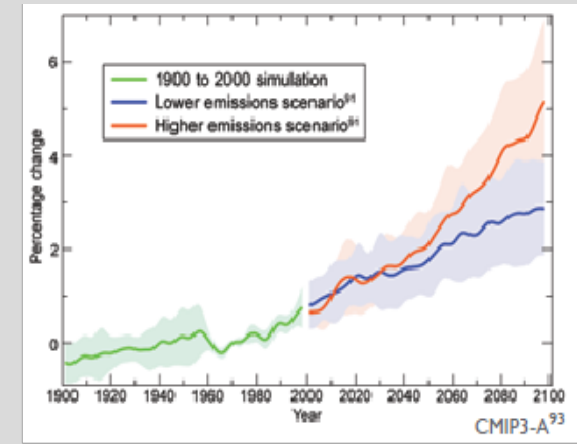
Global Average SLR
1900 to 2100



U.S. Average Temperature
1900 to 2100



Global Increase in Heavy Precipitation
1900 to 2100



Climate Change: projections

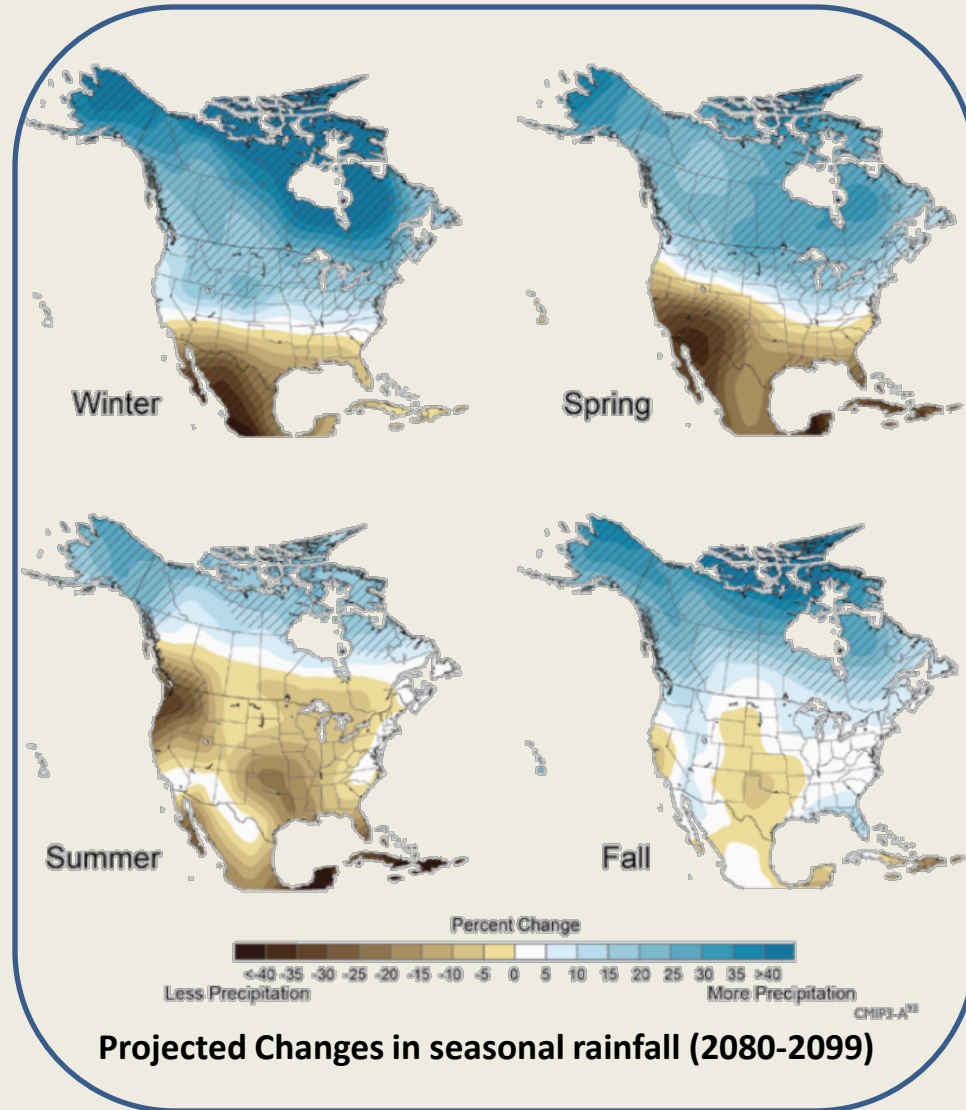
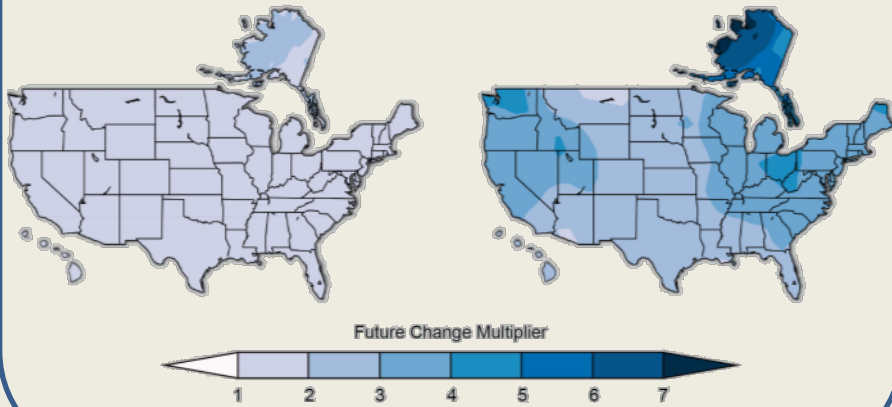
Scenarios

- Population, regulation, emissions

Projected Changes in 1 in 20 year daily rain intensity (2081-2100)

Low Pathway (RCP 2.6)

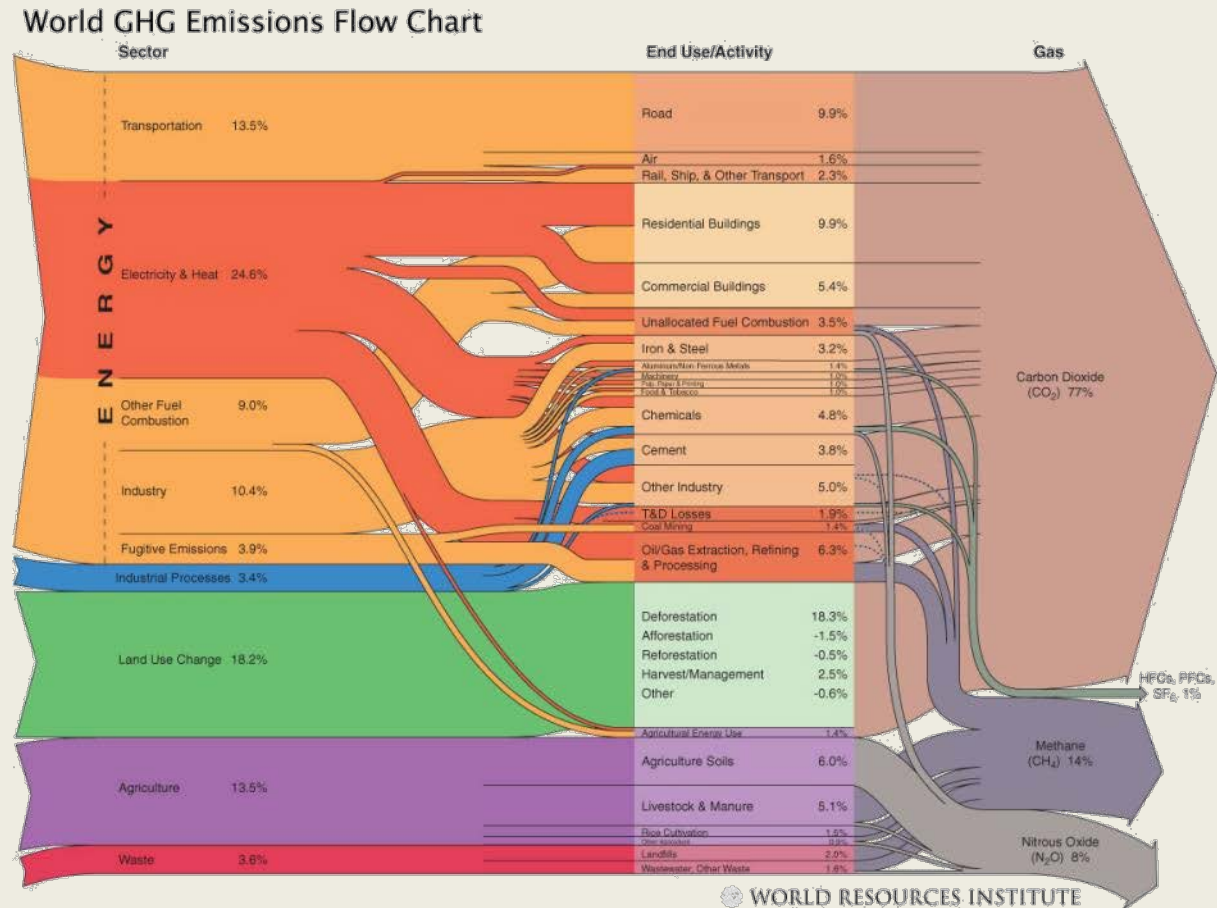
High Pathway (RCP 8.5)



Agriculture impacts on climate

GHG emissions:

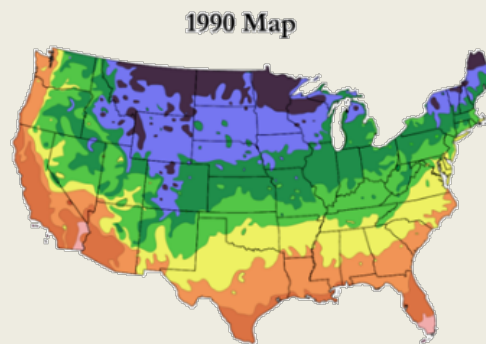
- Globally, 14% of GHG emissions from agriculture
- In the U.S., 8% of GHG emissions from agriculture



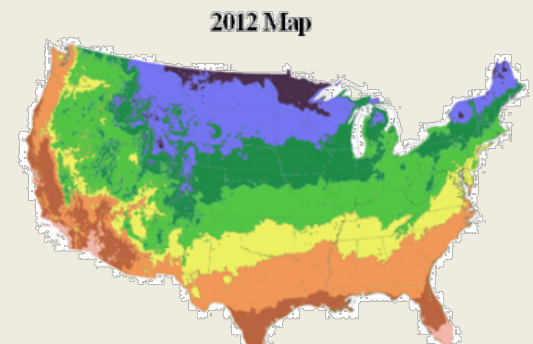
Climate change: impacts on agriculture (today!)

Diversity of impacts

- Iowa – spring rains and drainage (fewer workable days); drier fall
- Temperate regions – longer growing seasons
- Warmer nights (bad for plants)
- Higher humidity
- New pest problems



After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1455, Issued January 1990

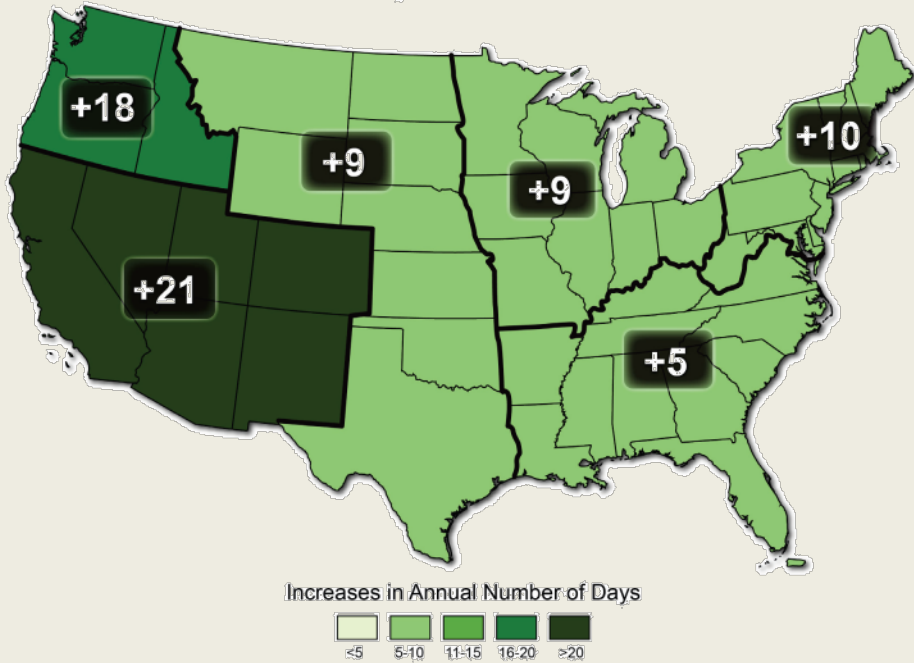


Re-colored version of the 2012 USDA Plant Hardiness Zone Map (available at: <http://planthardiness.ars.usda.gov/PHZMWeb/>)

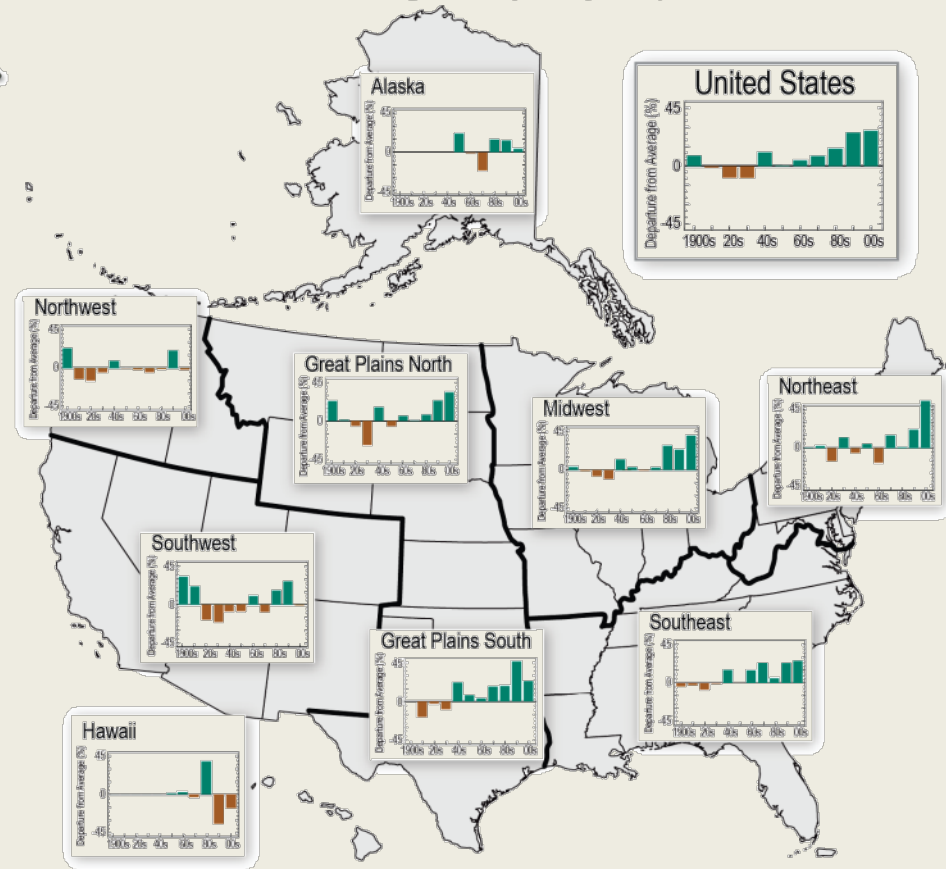


Climate change: impacts on agriculture (today!)

Observed Changes in Frost-Free Season



Observed Changes in Very Heavy Precipitation



The frost-free season length, defined as the period between the last 5 occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has increased in each U.S. region during 1991-2011 relative to 1901-1960. Increases 7 in frost-free days correspond to similar increases in growing season length.

Climate change: impacts on agriculture (today!)

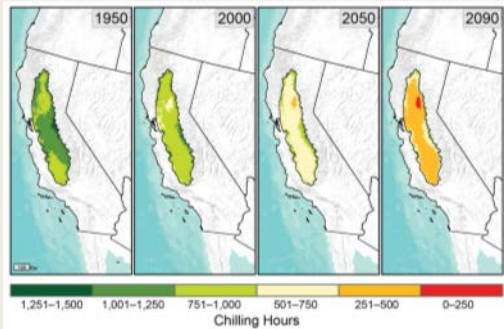
Resources to explore climate change and impacts on different sectors

- NCA info: <http://www.globalchange.gov>
- For looking at historic trends in climate, these are the best I've seen:
 - <http://www.ncdc.noaa.gov/cag/time-series>
 - <http://nidis1.ncdc.noaa.gov/GHCNViewer/>
 - <http://www.ncdc.noaa.gov/temp-and-precip/time-series/>

Climate change: projected impacts on agriculture (a best guess)

- CO₂ fertilization: carbon dioxide + water + light energy → carbohydrate + oxygen
- Weed competition
- Chill hour declines

PHOTOSYNTHESIS



- More water stress might result from more intense rainfall (less rain infiltration)
- Changing ranges of insects and diseases
- Temperature stress in animal agriculture

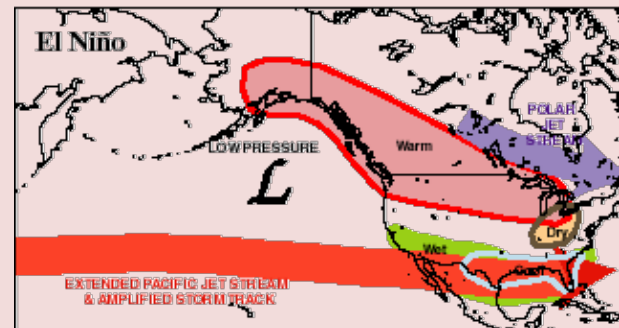
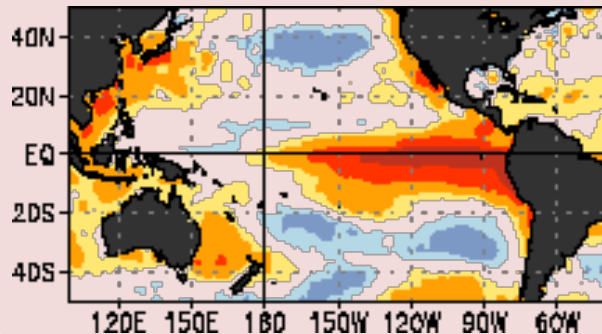
Climate Resilience in Agriculture: from Variability to Change

What can be changed to increase resilience?

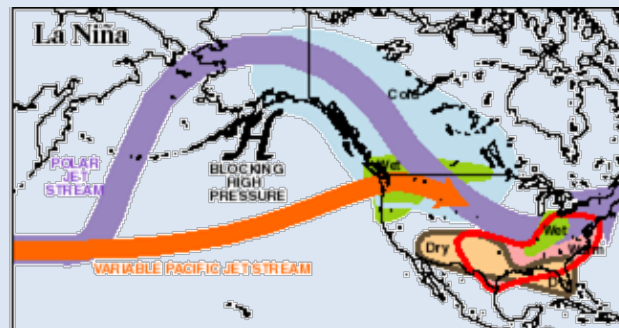
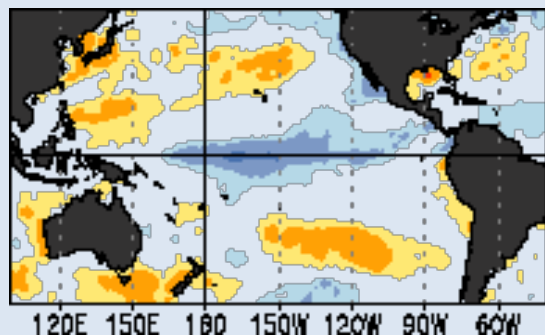
Reducing risks from climate variability: no regret changes

ENSO (El Niño Southern Oscillation)

- Major driver of seasonal and year-to-year climate variability; 3 phases – Neutral, El Niño, La Niña



El Niño

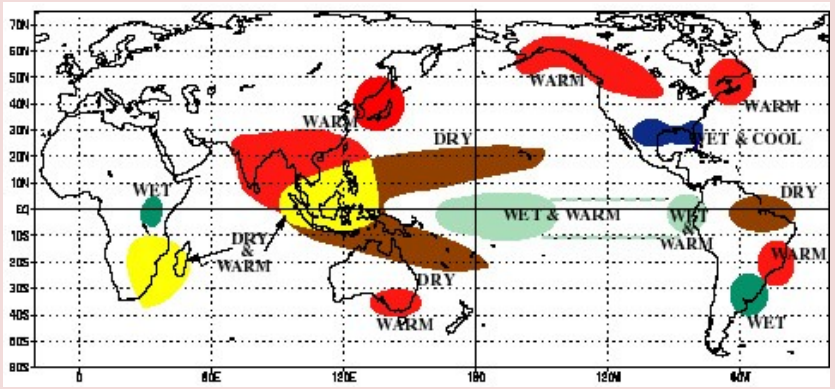
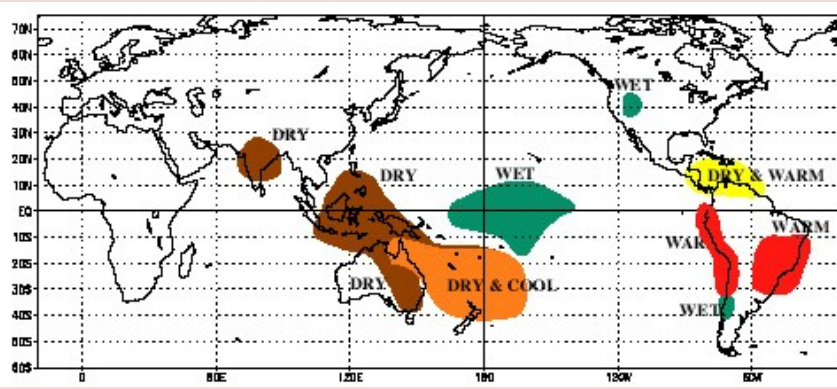


La Niña

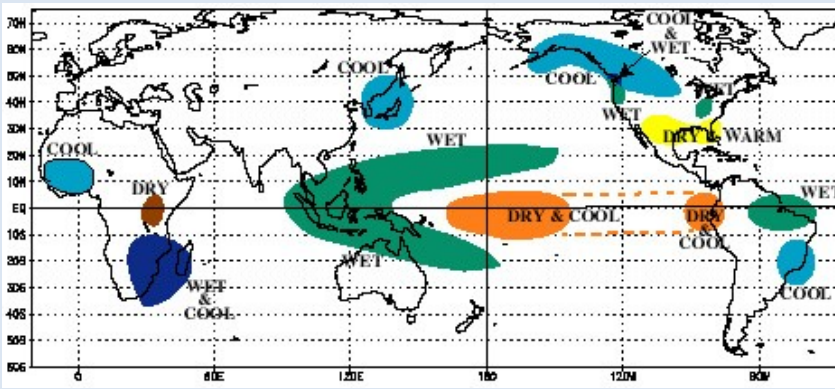
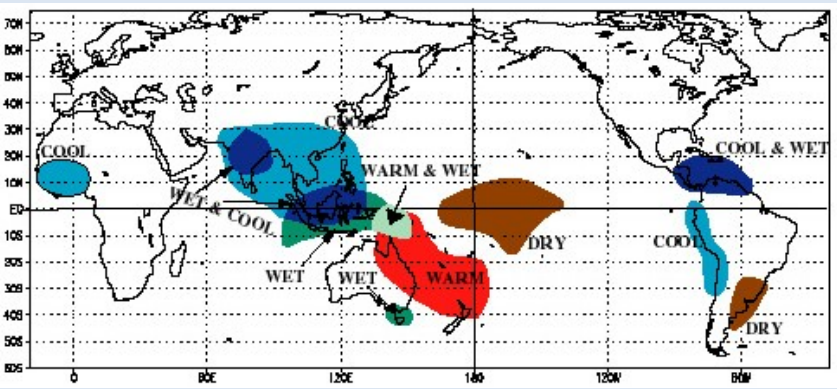
Climate Resilience in Agriculture: from Variability to Change

June to August

December to February

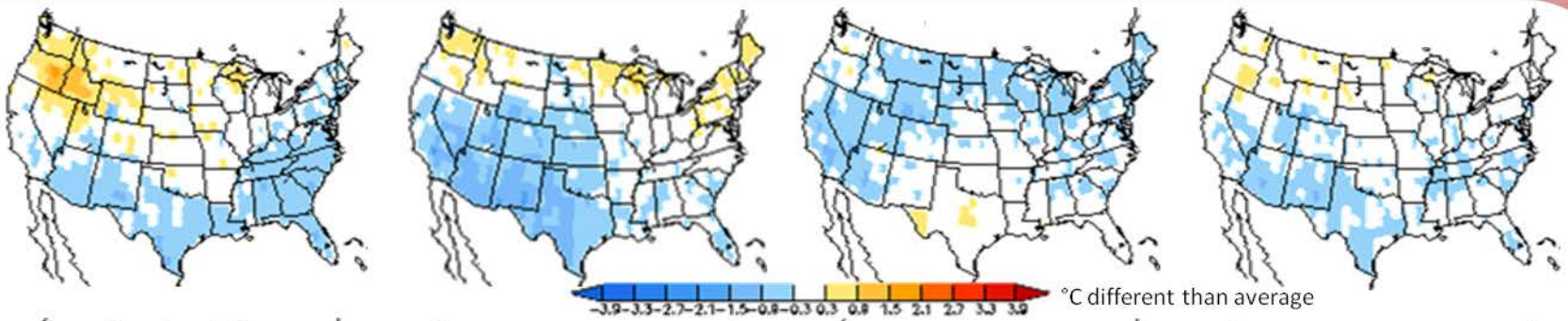


El Niño



La Niña

changes from average
Temperature



°C different than average

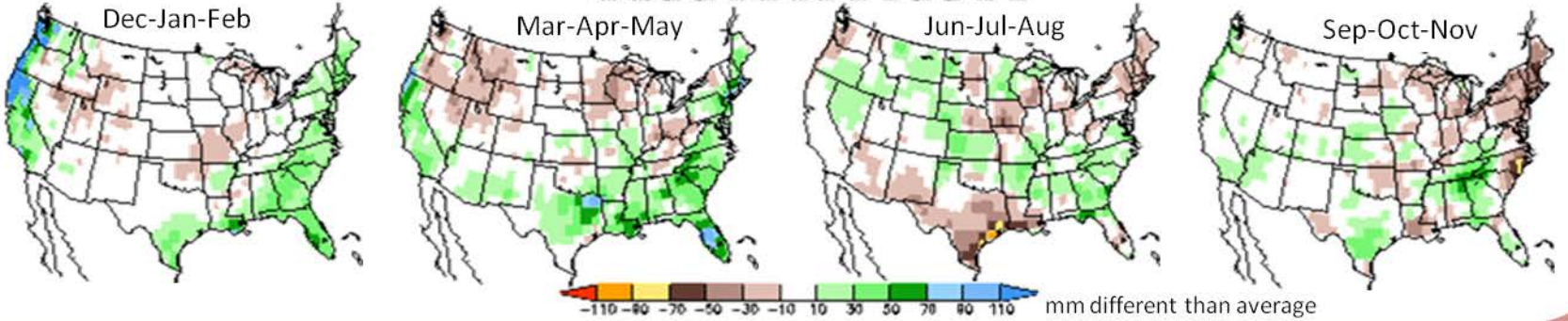
Dec-Jan-Feb

Mar-Apr-May

Jun-Jul-Aug

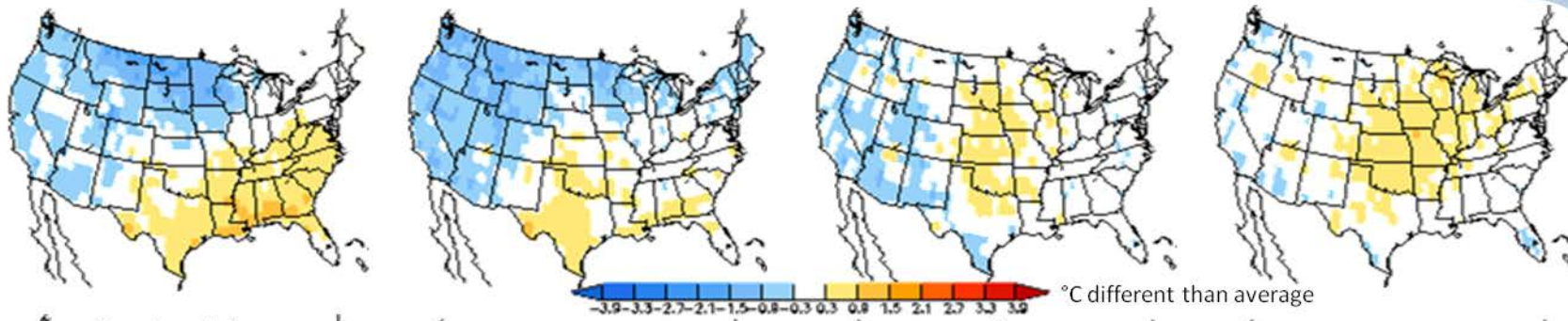
Sep-Oct-Nov

El Niño
Precipitation



mm different than average

changes from average
Temperature



°C different than average

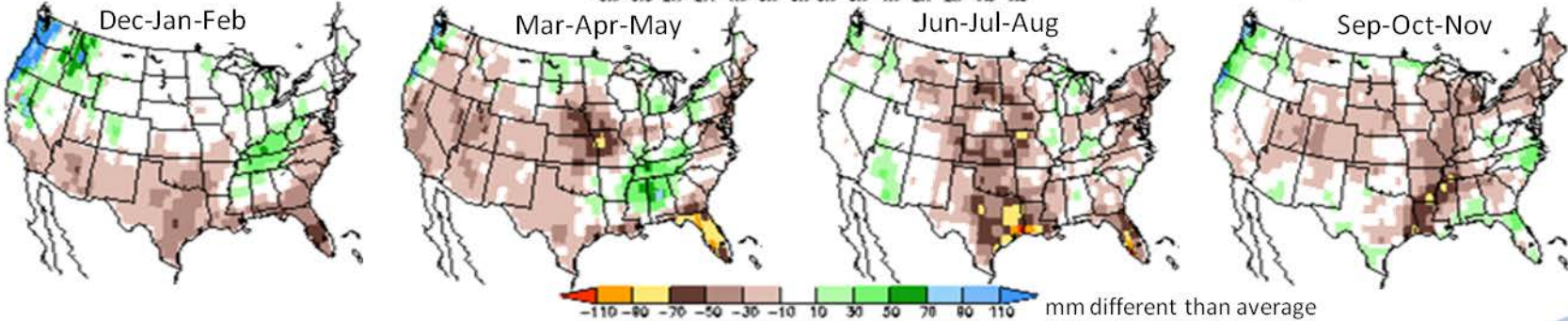
Dec-Jan-Feb

Mar-Apr-May

Jun-Jul-Aug

Sep-Oct-Nov

La Niña
Precipitation



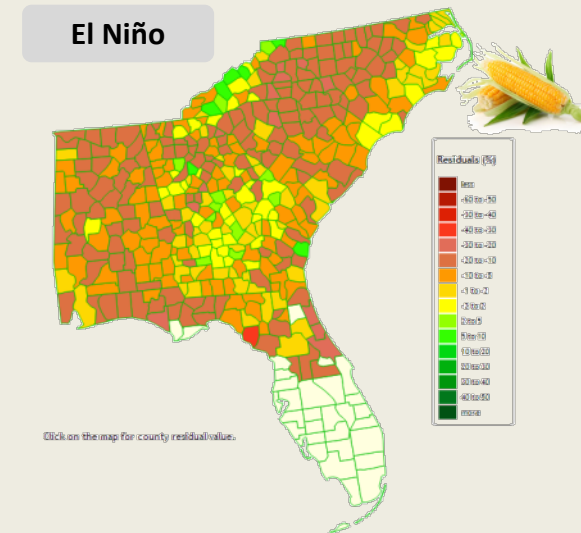
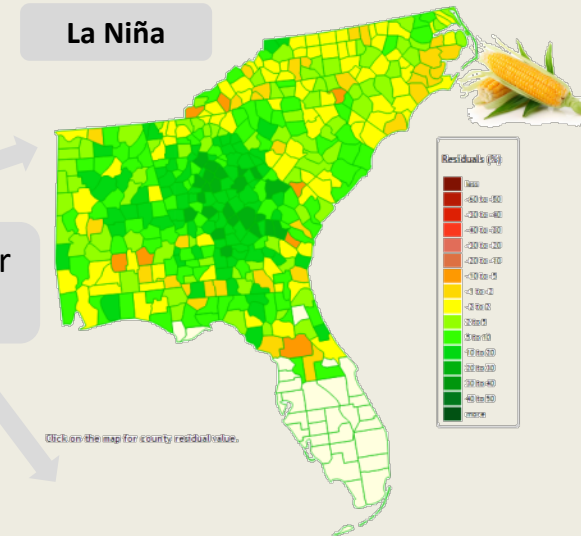
mm different than average

Climate Resilience in Agriculture: from Variability to Change

ENSO: management possibilities...

- crop and variety selection
- planting date
- plant population (Pioneer example)
- N fertilization
- timing of establishment and termination of winter cover crops
- insurance coverage adjustments
- Outside of ag. – water supply forecasting (Tampa Bay Water)

Corn yield residuals for El Niño and La Niña



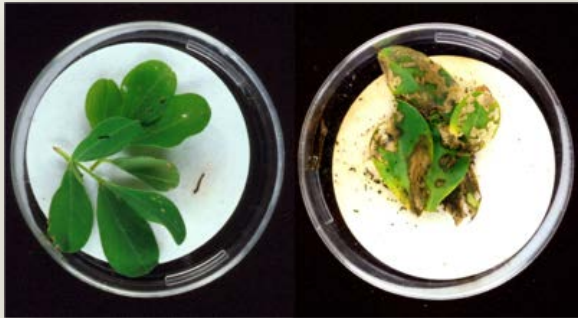
Climate resilience in agriculture

1) improving existing crop cultivars and developing new crops, 2) devising new cropping systems and methods for managing crops in the field.... **GxE interactions**

- Plant genetics 1)
- Soil-water holding capacity 2)
- Rainfall partitioning / soil conservation
- Diversification
- Irrigation: little expansion, mostly improvement in delivery technologies
- Input-use efficiency: spatial management

Climate resilience in agriculture

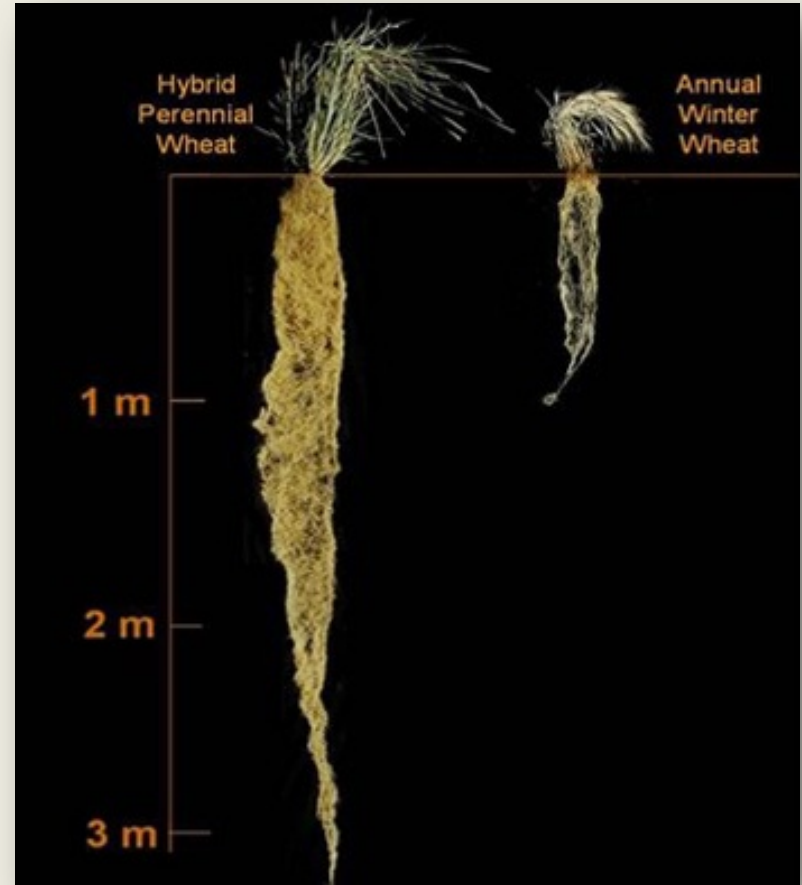
Current advances – plant genetics



BT-producing crops



herbicide-resistant crops



Perennialization – wheat, sunflower...

Climate resilience in agriculture

Current advances – farm management

- Conservation tillage
- High-residue cover crops
- Sod-based rotation



Climate resilience in agriculture

Connecting with producers... framing the issues

- Risk management
- Producers need short and long-term solutions
- Use of climate information in the context of market conditions

